Cluster Profile
Jaipur foundries

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Promoting Energy Efficiency in SMEs
SAMEEEKSHA

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Jaipur foundries

Overview of cluster

Location of foundry units in Jaipur
Source: Google map

Jaipur city is the capital of Rajasthan and is universally known as the Pink City. Jaipur means "city of victory" was founded in 1726 by Maharaja Jai Singh II. Jaipur is located about 260 km from the Indian capital, New Delhi and is well connected with an international airport along with railways and national highways. It is also a major hub for arts and crafts. The economy of Jaipur is fuelled by tourism, gemstone cutting and manufacturing of jewellery, luxury textiles, industries and information technology. Jaipur district has about 25,000 industries in 35 different industry estates. Cotton, wood/handicraft, leather, food industry, engineering and foundry industry are prominent in the cluster. Some of the large industries in Jaipur include National Engineering India Ltd (ball bearing), K C Mercantile Ltd (electronic energy meter), Hindustan Coca-Cola Beverages Pvt Ltd (cold drink), and Grasim Industries Ltd (cement). Major industrial exports from Jaipur includes ball bearing, electronic energy meter, paper, cement, transmission line & tower, synthetic & organic colour, hot rolled steel/cold rolled strips etc.

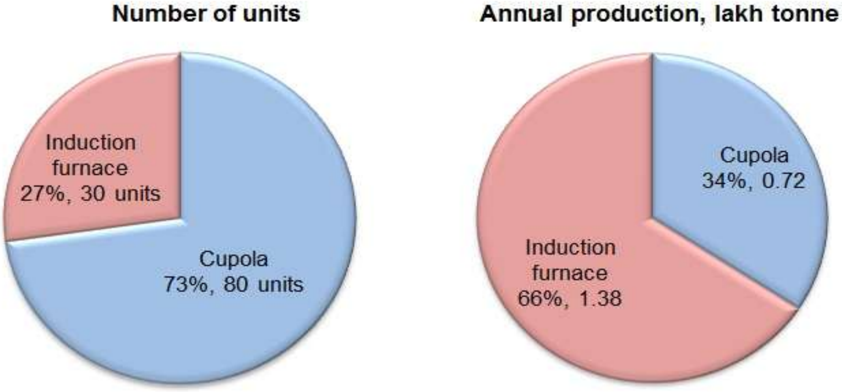
The beginning of commercial casting industries in India was in later half of 19^{th} century. However, the first casting unit in Jaipur was established in 1945. Over the years casting industries have grown at Jaipur and bacome a sizable cluster. Presently, there are 110 foundries in Jaipur producing around 215,000 tonne of castings every year. Foundry industries provide employment to about 7,000 people.

Foundry units are mainly located in Vishwakarma, Jhotwara, Jetpura industrial areas. Few foundries are being establised around Kaladera industrial area, RIICO and Sarna Dungar industrial area. Majority of cupola based foundries are over 30 years old. The total collective power demand of foundry cluster is about 35 MVA. Total annual turnover of foundries is Rs 850 crore; of this, about 10% coming from exports. There are nine export oriented foundries in the cluster.

The cluster has foundries which mainly use green sand moulding. A few foundries employ investment casting. Some of the major foundries in the cluster include Universal Autofoundry Ltd, Precision Autocastings Pvt Ltd, Agrasen Engineering Industries Ltd and Sigma Electric. Major castings buyer from cluter are Public Health Engineering Department (PHED), Volvo, Eicher Truck & Buses, Sonalika, Escorts, Ashok Leyland, etc.

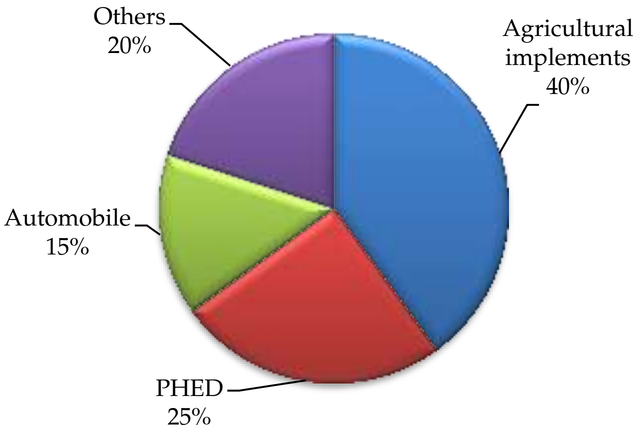
Product types and production capacities

Jaipur foundry cluster comprises 80 cupola based foundries and 30 induction furnace based foundries. Although, close to 73% of furnaces are cupola based, induction furnace segment accounts for about 2/3rd of total production in the cluster.



Share of cupola and induction furnace in Jaipur cluster

These foundries cater to the requirements of sectors such as automobile, general engineering parts, valves and pumps, agricultural implements and demands of PHED, etc. Agriculture implements account for about 40% of total production followed by the requirements of PHED (25%).



Product share from Jaipur cluster

The cluster procures raw material locally and from Delhi-NCR region. Based on average production levels, foundry units can be divided into (1) Category A (production level - 50 tonnes per month (tpm)), (2) Category B (production level - 150 tpm), and (3) Category C (production level - 500 tpm).

Categorization of foundries

Type	Number of units	Production (tonne/month)	Employment per unit	Turnover (Rs crore/year/unit)
Category A	60	50	20	1.5
Category B	30	150	50	5.0
Category C	20	500	200	30.0

A majority of the units (about 60 units) fall under category A; category B and C comprise 30 units and 20 units respectively. The total production of castings in the cluster is about 720 tonnes per day (about 216,000 tonne per year). Category C foundries operate round-the-clock (three shifts) with a majority of the units operate at less than 50% capacity utilization. The major raw materials used include base metals (scrap, pig iron, borings scrap and foundry returns) and alloys (ferro-silicon, ferro-manganese, etc.). The major products produced are CID joints, sanitary & pipe fittings, automobile components, agricultural implements, engine & machine parts and grinding media.

Major castings produced in Jaipur cluster

Energy scenario in the cluster

Coke and electricity are the major sources of energy for the melting in foundries. Electricity is used to drive equipment such as blower, sand mixer, sand muller, air compressor, pump and motor and for lighting. Most of the induction furnace based foundries and a few cupola foundries use LPG. Electricity to foundries is supplied by Jaipur Vidyut Vitran Nigam Limited, Government of Rajasthan (JVVNL). The cupola foundries have low tension (LT) connection at 400 V voltage and fall under connection MP/LT-6 category. The induction furnace based foundries have high tension connection at 11 kV voltage (for contract demand up to 1500 kVA) or 33 kV voltage (for contract demand more than 1500 kVA) and fall under connection LP/HT-5 category.

Low ash coke (ash content less than 12%) is procured from Saurashtra through traders. LPG is used in a number of applications like core heating, ladle preheating, gas cutting, etc. LPG is procured from local market. Almost all foundries have diesel generator (DG) sets which are operated only to meet emergency demands during unscheduled outages. The consumption of diesel is insignificant in overall energy consumption. The details of major energy sources and tariffs are shown in table.

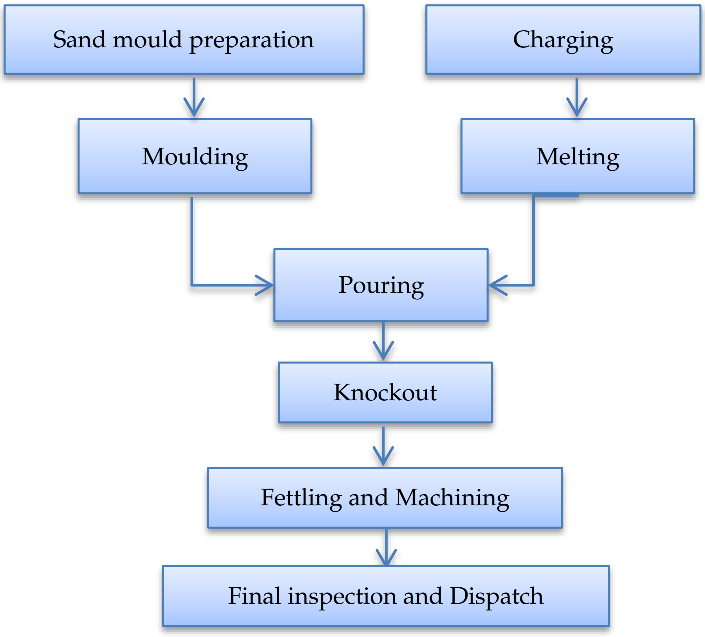
Prices of major energy sources

Raw material	Remarks	Price
Coke	Low ash	Rs 30,000 - 34,000 per tonne
	High ash	Rs 16,000 - 18,000 per tonne
Electricity	LP/HT-5	Energy charge : Rs 7.30 per kWh Demand charge: Rs 185 per kVA per month
	MP/LT-6	Energy charge : Rs 7.00 per kWh Demand charge: Rs 75 per hp per month

Production process

Majority of foundries in the cluster use green sand moulding process for producing castings. The major steps of green sand moulding process are mould sand and core preparation, charge (raw material) preparation followed by melting, pouring, knockout and finishing (fettling and machining). The steps are explained below.

1. **Mould sand preparation.** Fresh sand is mixed with bentonite and other additives and mixed in muller to make green sand. Plants use sand mixers and sievers in general, few plants have complete sand handling plant equipped with sand cooler. Few units follow resin sand, investment casting process.
2. **Moulding.** The mould sand is pressed manually or by pneumatic machines on the pattern to prepare the mould. Generally, the mould is divided into two halves - the cope (upper half) and the drag (bottom half), which meet along a parting line. Both mould halves are contained inside a box, called a flask, which itself is divided along this parting line. The mould cavity is formed by packing sand around the pattern (which is a replica of the external shape of the casting) in each half of the flask. The sand can be packed manually, but moulding machines with pressure to pack the sand are also commonly used.
3. **Charging.** The raw material such as pig iron, scrap, foundry returns and other alloys are weighted and charged in the induction furnace for melting.
4. **Melting.** The metal charge is melted in induction or cupola furnace. The operator adjusts chemistry by alloying and brings the temperature to required level. This process runs in parallel with moulding.
5. **Pouring.** After melting, the molten metal is transferred and poured into the moulds using ladles operated either manually, by mono-rail or using overhead cranes.
6. **Knock-out.** The moulds are left to cool for certain time after which the castings are knocked-out from the mould either manually or using a vibratory knock-out machine.
7. **Finishing.** The finishing operation involves removal of runners/risers, shot blasting and cleaning of castings. This is followed by fettling and machining. In case of steel casting heat treatment is also an integral part finishing operations.



A simplified process flow diagram of a typical foundry is given in the figure.

Technologies employed

Some of the major foundry processes/equipment are described below.

(i) Melting furnace

Induction furnace

The induction based units melt raw material using medium frequency induction furnace. Although induction furnace units account for only 27% of total number of foundries in the cluster, they account for about 66% of total production at cluster level. A

Induction furnace

majority of the units employ induction furnaces of 300 kg, 500 kg or 1,000 kg capacity crucible. Most of the induction furnaces are SCR (Silicon controlled rectifier) based. The specific energy consumption of furnace for melting varies in range of 600–750 kWh per tonne for iron castings.

Cupola furnace

Among the cupola based units, a majority of units use conventional single blast cupola for melting. Only a few units use "Divided Blast Cupola" (DBC) with inadequate design features. The 'specific energy consumption' (SEC) of the cupola varies in range of 100–150 kg coke per tonne for molten metal. In terms of coke to metal ratio, it translates into 1:10 to 1:7. In terms of percentage of coke the figures are 10-15%. All the figures are on charging coke basis (i.e. total coke used during a batch except bed coke).

Cupola

(ii) Moulding and core preparation

Preparation of the mould is an important process in casting industry. Cores are placed inside moulds to create void spaces. Cores are baked in ovens which are usually electrical fired. Moulds are either prepared manually or using pneumatic moulding machines (ARPA lines). Three foundries use 'high pressure moulding lines' (HPML).

(iii) Sand preparation

Sand preparation is done using sand mixers and sand sievers. Sand mixers have typical batch size of 100 to 500 kg. The connected load of these mixers is in the range of 10 to 30 kW. Few plants have sand handling plant along with sand cooler of capacity 5 to 20 tonnes per hour, the connected load of such plants is about 75 to 100 kW.

(iv) Auxiliary system

Air compressor

The foundries utilize compressed air for a number of process applications like mould preparation, pneumatic fettling and application of cleaning of mould, core and general cleaning. Typically foundry have compressor with "Free Air Discharge" (FAD) of 75–300 cfm with a power rating of 15–45 kW.

Pump

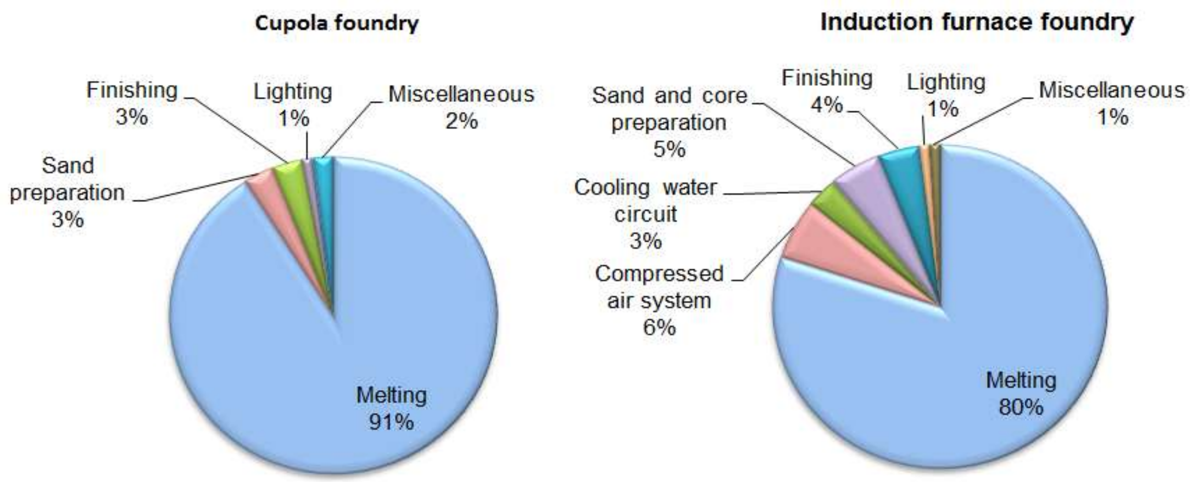
Induction furnaces require cooling of coils in crucible and the electronic panel. Two pumps running on DM water serve this purpose. One pump runs on raw water through cooling tower and cools the DM water in a heat exchanger.

Air compressor

Pumps

Energy consumption

The foundries use electricity, coke and LPG for their energy requirements. Melting accounts for a major share of about 75-80% of total energy consumed in a foundry unit. The other important energy consuming areas include moulding, core preparation, sand preparation and finishing operations. The steel foundries have heat treatment process which accounts for about 4-5% of total energy consumption. The share of energy usage in a typical iron and steel foundry is given in the figure.



Typical energy use in a foundry

(i) Unit level consumption

The SEC level varies considerably in a foundry depending on the type of furnace and degree of mechanisation. The SEC of furnace for melting varies in range of 600–750 kWh per tonne (induction furnace) and 100–150 kg coke per tonne (cupola) as shown in the tables.

Typical energy consumption - Cupola based foundries

Production – saleable castings (tonne/year)	Electricity (kWh/yr)	Coke (tonne/year)	Total energy (toe/year)	Annual energy bill (million INR)
600	20,000	80	56	2.9
1800	85,000	220	156	8.2

Typical energy consumption - Induction furnace based foundries

Production – saleable castings (tonnes/year)	Electricity (kWh/year)	LPG (tonne/year)	Total energy (toe/year)	Annual energy bill (million INR)
1800	2,000,000	3	176	15.8
6000	7,000,000	15	621	55.6

(ii) Cluster level consumption

The total energy consumption of foundry unit in the cluster is estimated to be 20,630 tonnes of oil equivalent (toe). The estimated energy bill of the cluster is about Rs 160 crore which corresponds to about 19% of the total production cost.

Energy consumption of the Jaipur foundry cluster (2016)

Energy type	Annual consumption	Equivalent energy (toe)	GHG emissions (tonne CO_2)	Annual energy bill (million INR)
Electricity	163 million kWh	14,010	156,385	1270
Thermal	9200 tonne (Coke) 330 tonne (LPG)	6,620	27,775	335
	Total	**20,630**	**184,160**	**1,605**

Energy saving opportunities and potential

Some of the major energy saving opportunities in foundry units of Jaipur cluster are discussed below.

(i) Replacement of existing conventional cupola with divided blast cupola

For cupola based foundries, replacement of conventionally designed cupolas with an energy efficient DBC is the major option. The existing designs of DBCs in the cluster are reported to have a coke consumption of about 100–150 kg per tonne of liquid metal. With a properly designed DBC, a coke consumption of about 80 kg per tonne of liquid melt can be achieved. The estimated energy savings with an energy efficient DBC is 25-30% as compared to existing DBC design. The investment on energy efficient DBC is expected to pay back within one year on account of coke saving alone.

Divided blast cupola

(ii) Replacement of inefficient induction furnace with energy efficient IGBT furnace

Older induction furnaces operating in the cluster have an SEC level of 750 kWh or more per tonne of molten metal. These inefficient furnaces can be replaced with energy efficient IGBT (Insulated Gate Bipolar Transistor) furnaces. With IGBT furnaces, an SEC level of about 550 kWh per tonne of molten metal can be achieved. The capital investment made on EE furnace has attractive payback period of less than one year. The other advantages of an energy efficient 24-pulse IGBT furnace include higher power factor (~0.97) and lower total harmonic hormanic distortion in current.

IGBT Furnace

(iii) Lid mechanism for induction furnace

Most of the induction furnaces operating in the cluster do not have lid mechanism resulting in higher heat losses due to radiation and convection. About 6% of energy input is lost through radiation and convection losses due to non-use of lid mechanism. A lid mechanism helps in reducing these losses and the payback period for investment on of lid mechanism is less than one year.

(iv) Reduction in rejections

A large number of foundries have high rejection level (~10%), which can be brought down to below 5% through improved process control. This can be achieved with nil or marginal investments. As the units do not produce multiple products and the castings are limited, the rejection level can be reduced through process improvements.

(v) Adoption of best operating practices in cupola melting

Efficient operation of cupola furnace depends on adoption of best operating practices (BOP) in each step of melting that would help in optimising operating parameters. At present, a majority of the foundries do not use any "Standard Operating Practices" due to non-availability of trained manpower at their facilities. The potential coke saving with adoption of BOP in a cupola system is 5%.

(vi) Cleaning of foundry returns re-melting

Foundry returns i.e. runners and risers constitute a significant share of charge material. A majority of foundry returns also have moulding sand sticking to their surfaces, which constitutes for about (4-5% of total weight of foundry returns. Non-removal of this sand would lead to slag formation and increased energy consumption levels. By using shot/ tumble blast, the sand be cleared from foundry returns before being charged into the furnace. Shot/ tumble blasting of foundry returns would thus help in considerable energy saving and would require marginal or no investments.

(vii) Providing glass wool cover for ladle

The ladles used for transfer of molten metal from furnace to moulds are usually not covered resulting in heat losses. This can be reduced by providing glass wool covers for ladles and would require very low investment.

(viii) Replacement of inefficient pumps with energy efficient pumps

Induction furnace units use cooling water circuit. The pumps used in induction furnaces are generally inefficient as selection of motors is not done on technical basis. This results in higher power consumption. The inefficient pumps may be replaced with energy efficient pumps. The investments are paid back in a year or two.

Energy efficient pump

(ix) Retrofitting air compressor with variable frequency drive

During normal operation, an air compressor operated on unloading position for more than half the time. Installation of "Variable Frequency Drive" (VFD) to the air compressor will minimise the unload power consumption. The investment is about Rs 2-3 lakh and has a payback period of about 2 years.

(x) Arresting compressed air leakage

In a large number of foundry units, air leakages in piping system are quite high (above 20%) and generally go unnoticed. Compressed air is an expensive utility in a plant. The compressed air leakage can be brought down to about 5% with good housekeeping measures which require no or very low investments.

(xi) Replacement of rewound motors with energy efficient motors

Motor burn-out is not a rare phenomenon in foundries; this is a result of number of factors such as poor power quality, overloading, etc. Rewinding of motors is a cheaper option followed which however results in a drop in motor efficiency by 3–5%. It would be better to replace old motors which have undergone rewinding two or more times with EE motors (IE3 efficiency class). Use of EE motors would result in significant energy savings with a simple payback period of 2 to 3 years for the investments made.

(xii) Replacement of inefficient lighting with energy efficient lighting

The foundry units use fluorescent tube light (FTL-T12) and mercury vapour lamp (HPMV) for lighting. Some units use CFLs. Replacing them with HPMV with induction lamp and FTL-T12 with FTL-T5 can lead to energy saving of around 20–30%.

Major stakeholders

There are two major industry associations related to the foundry industry in Jaipur, Institute of Indian Foundrymen and Foundry Owners Association. The major industry associations are the following:

- *IIF (Institute of Indian Foundrymen)*: The Jaipur chapter of IIF is an important chapter in the Northern Region. They represent select foundries, raw material suppliers and other stakeholders.
- *FOA (Foundry Owners Association)*: The FOA is the state level association for foundries. Most of micro and small scale cupola foundries are its members.

The "District Industries Centre" (DIC), Jaipur provides several incentives to MSMEs e.g. Back Ended Interest Subsidy Scheme in which MSMEs can avail 3% interest subsidy (subject to a maximum of Rs 10 lakhs) on term loans loan on technology. The MSME Development Institute (DI), Jaipur provides assistance for the promotion and Development of MSMEs. They also implement various central and state government schemes for MSMEs including Credit Linked Capital Subsidy Scheme (CLCSS) and Technology Upgradation Scheme (TEQUP).

Cluster development activities

MSME-DI, Jaipur organizes awareness workshops for the foundries on pollution, environment, energy efficiency and lean manufacturing. Apart from this there have been no major cluster level initiatives for Jaipur foundries.

About TERI

A dynamic and flexible not-for-profit organization with a global vision and a local focus, TERI (The Energy and Resources Institute) is deeply committed to every aspect of sustainable development. From providing environment-friendly solutions to rural energy problems to tackling issues of global climate change across many continents and advancing solutions to growing urban transport and air pollution problems, TERI's activities range from formulating local and national level strategies to suggesting global solutions to critical energy and environmental issues. The Industrial Energy Efficiency Division of TERI works closely with both large industries and energy intensive Micro Small and Medium Enterprises (MSMEs) to improve their energy and environmental performance.

About SDC

SDC (Swiss Agency for Development and Cooperation) has been working in India since 1961. In 1991, SDC established a Global Environment Programme to support developing countries in implementing measures aimed at protecting the global environment. In pursuance of this goal, SDC India, in collaboration with Indian institutions such as TERI, conducted a study of the small-scale industry sector in India to identify areas in which to introduce technologies that would yield greater energy savings and reduce greenhouse gas emissions. SDC strives to find ways by which the MSME sector can meet the challenges of the new era by means of improved technology, increased productivity and competitiveness, and measures aimed at improving the socio-economic conditions of the workforce.

About SAMEEEKSHA

SAMEEEKSHA (Small and Medium Enterprises: Energy Efficiency Knowledge Sharing) is a collaborative platform set up with the aim of pooling knowledge and synergizing the efforts of various organizations and institutions - Indian and international, public and private - that are working towards the development of the MSME sector in India through the promotion and adoption of clean, energy-efficient technologies and practices. The key partners are of SAMEEEKSHA platform are (1) SDC (2) Bureau of Energy Efficiency (BEE) (3) Ministry of MSME, Government of India and (4) TERI.

As part of its activities, SAMEEEKSHA collates energy consumption and related information from various energy intensive MSME sub-sectors in India. For further details about SAMEEEKSHA, visit http://www.sameeeksha.org